SB761
U7R6
80-2

Forest Insect and Disease Management

3430
BIOLOGICAL
EVALUATION R2-80-2

Root Disease Surveys of Selected Managed Conifer Stands on the Routt, Gunnison, and White River National Forests in Colorado

MARCH 1980

LIBRARY
APR 16 1980
ROCKY MOUNTAIN STATION

Rocky Mountain Region

U.S. Department of Agriculture Forest Service

DUE TO THE HIGH COST OF COLOR PHOTOS, A LIMITED NUMBER WERE AVAILABLE. THIS COPY MINUS PAGES 8 & 9.

3430
BIOLOGICAL
EVALUATION R2-80-2

Root Disease Surveys of Selected Managed Conifer Stands on the Routt, Gunnison, and White River National Forests in Colorado

MARCH 1980

PREPARED BY: Robert L. James
Robert L. James
Plant Pathologist

Linnea S. Gillman
Linnea S. Gillman
Biologist (Retired)

APPROVED BY:

G. L. Downing
G. L. DOWNING
Staff Director
Forest Insect and Disease Management

Larry D. Henson
LARRY D. HENSON
Deputy Regional Forester
State and Private Forestry

Forest Insect and Disease Management
State and Private Forestry
Rocky Mountain Region
USDA Forest Service
11177 W. 8th Avenue
Lakewood, Colorado 80225

ACKNOWLEDGEMENTS

Assistance of D. Hildebrand, C. Flanagan, R. Torbet, and P. Beemsterborer with the field data collection is appreciated. Technical assistance of D. W. Johnson is also appreciated.

ABSTRACT

Evaluations of the incidence of root diseases in four young conifer stands within three National Forests (Routt, Gunnison, and White River) in Colorado were conducted. Sampled stands consisted of naturally-regenerated lodgepole pine and spruce-fir on harvested sites. Root disease caused by *Armillariella mellea* was common in all sampled stands; incidence ranged from 0.8 to over 13 trees per acre. Most diseased trees were near stumps which probably served as inoculum sources. Evaluation plots were established in each stand to monitor disease development, symptom production, and spread over time.

INTRODUCTION

Root diseases can potentially affect the management of young commercial forest stands. These diseases may impact stands by causing mortality and growth loss. Reduction of stocking below desired levels can affect productivity. Little is known about the identity, distribution, and impact of root diseases in the Rocky Mountain Region. The following descriptions briefly outline previous root disease work in the Region.

Black stain root disease caused by *Ceratocystis* (= *Verticicladiella*) *wageneri* Goheen & Cobb (2) was first discovered in Colorado in 1942 on pinyon (*Pinus edulis* Engelm.) (24). The disease has only been found west of the Continental Divide (14). Ponderosa pine (*Pinus ponderosa* Laws.) and Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Mayr.) Sudw.) are other reported hosts in Colorado (10, 14). Black stain root disease causes extensive pinyon mortality in Mesa Verde National Park in southwestern Colorado (11). An evaluation of the epidemiological aspects of the disease is underway in the Park. This work in addition to that conducted elsewhere in the West (3, 4) should improve our understanding of the disease.

Fomes annosus (Fr.) Cke. is an important cause of root disease in north temperate forest ecosystems. The fungus was first reported in Colorado in 1931 on Engelmann spruce (*Picea engelmanni* Parry) (22) and recently found on white fir (*Abies concolor* (Gord. & Glend.) Lindl.) (8, 9) and subalpine fir (*A. lasiocarpa* (Hook.) Nutt.) (10) in southern Colorado. *Fomes annosus* has also been reported in the Intermountain (23) and Northern Rocky Mountain Regions (27). The fungus was recently found in Arizona on corkbark fir (*A. lasiocarpa* var. *arizonica* (Merr.) Lemm.) (R. E. Wood and T. E. Hinds, personal communication). Therefore, it appears that *F. annosus* is widely distributed throughout the West and may be more important than previously thought.

The most widely distributed root pathogen in the Region is probably *Armillariella* (*Armillaria*) *mella* (Vahl. ex Fr.) Karst. This fungus has an extremely wide host range, including the following tree species in the Rocky Mountains: subalpine fir (7), white fir (10), lodgepole pine (*Pinus contorta* Dougl.) (12), ponderosa pine (25), pinyon (11), Rocky Mountain juniper (*Juniperus scopulorum* Sarg.) (13), and Engelmann spruce (6). This fungus is ubiquitous in forest ecosystems and incites disease only under specific conditions.

Because of the possible impact of root diseases in young commercial stands, evaluations were conducted to determine current disease levels and potential disease development within selected stands.

MATERIALS AND METHODS

Areas with suspected root disease activity were located with aerial photographs and by roadside reconnaissance within young, managed stands. Four stands, with regeneration 3to 7 feet high on three National Forests (Routt, Gunnison, and White River) were selected for survey (Table 1, Fig. 1). Selected stands were delineated from surrounding areas on the basis of tree size and composition. Three of the stands (Powderhouse, Canyon Creek, and Last Chance) contained young lodgepole pine reproduction and one stand (Mill Creek) contained spruce-fir regeneration. At least six trees adjacent to selected stands were measured for height, diameter (DBH), and age to determine site index. One variable plot was used to determine basal area (10 BAF) (Table 1).

Transects with fixed-radius plots established every chain were run through selected stands. Fixed-radius plots were 0.01 acre in size if there were 10 or more trees per plot and 0.1 acre if there were less than 10 trees per plot. Transects were run one chain apart. The survey goal was to establish 65-100 plots within selected stands.

The following data were recorded within each fixed plot: total number of trees and number of live and dead trees with and without root disease symptoms. Observed root disease symptoms included foliage color (yellow, red, and brown) and resin exudation and wood impregnation around the root collar. Trees were also examined for signs of root pathogens such as mycelial fans, rhizomorphs (brown-black, root-like fibers around the base of infected trees), and sporophores. No isolations from wood samples were made.

At least four plots were established in each stand to evaluate disease symptom development and epidemiology. Plot descriptions are presented in the Appendix. Plots were located within active disease centers containing recently dead or dying trees. Sufficient non-symptomatic trees were included to monitor spread within infection centers. A stump, which might have served as the initial inoculum source for infection of surrounding trees, was arbitrarily chosen as the center of each plot. All plot trees were referenced to the center stump by azimuth and distance. Each live plot tree was identified by a numbered metal tag and tree height and foliage

Table 1. Characteristics of commercial stands selected for survey of incidence and distribution of root disease.

Site	National Forest	Ranger District	Legal Description	Species	Site Factors [1]				
					Basal Area per Acre	Site Index [2]	Ave. DBH (inches)	Ave. Hgt (feet)	Ave. Age (years)
Mill Creek	Routt	Hahn's Peak	T10N, R86W, Sec. 34	Spruce-fir	85	40	7.8	40.7	86
Powderhouse	Gunnison	Cebolla	T50W, R4E, Sec. 22	lodgepole pine	115	40	8.6	51.3	185
Canyon Creek	Gunnison	Cebolla	T50N, R4E, Sec. 36	lodgepole pine	75	30	6.7	39.8	83
Last Chance	White River	Sopris	T8S, R83W, Sec. 14	lodgepole pine	90	40	8.0	45.6	90

1/ From at least six dominant/codominant trees adjacent to the sample site.

2/ Site index base = 100 years

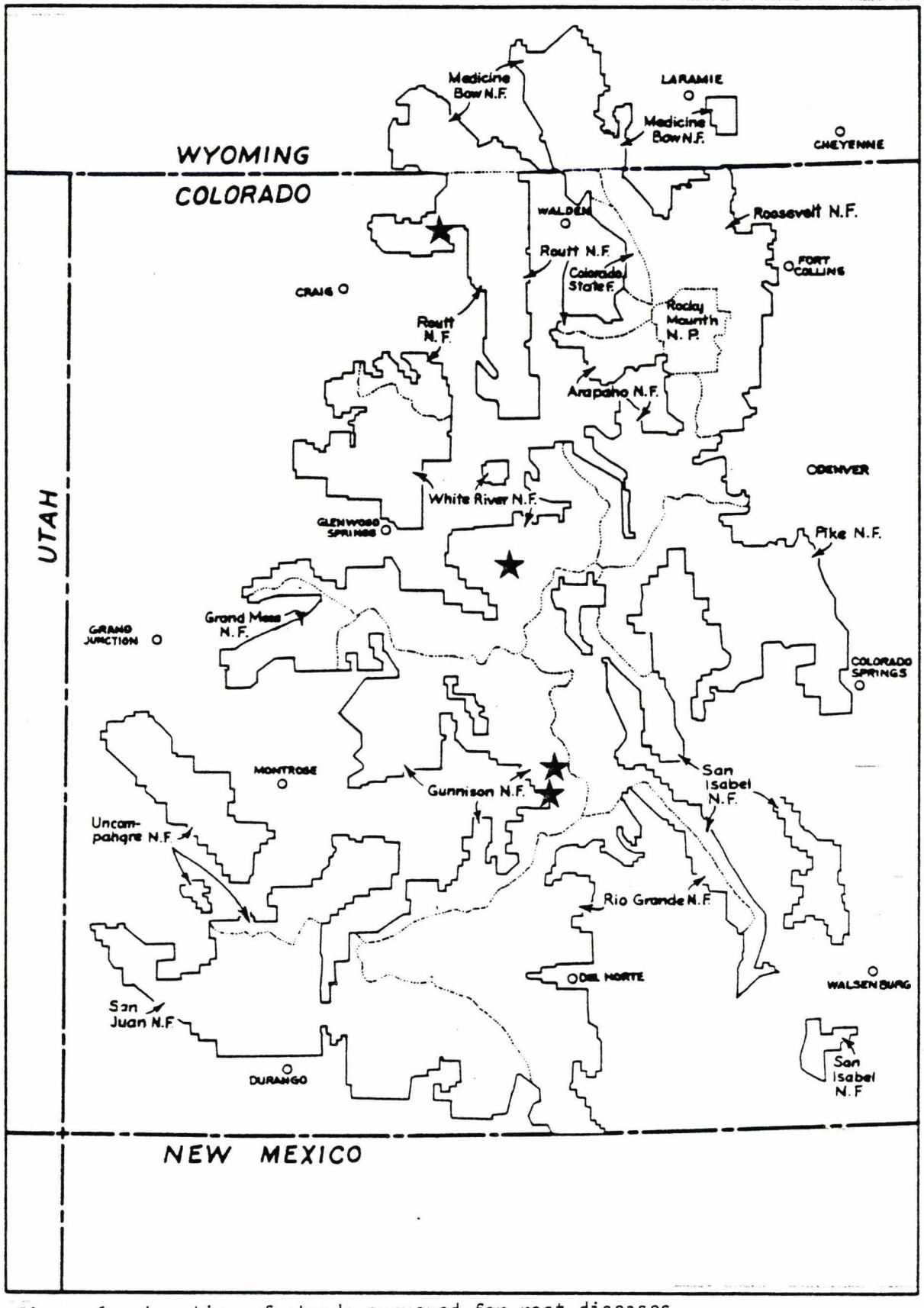

Figure 1. Location of stands surveyed for root diseases.
(★=stands surveyed)

condition class [1/] tallied. Presence of root disease was also determined using techniques similar to the transect survey.

RESULTS AND DISCUSSION

Armillariella mellea was the only pathogen consistently associated with root-diseased trees in the four stands sampled. Identification of causal organisms encountered in the field was based on visual symptoms and signs; therefore, other pathogenic organisms that could not be identified in this manner may have occurred singly or in conjunction with *A. mellea*.

Trees infected with *A. mellea* were usually located near stumps (Fig. 2). The fungus probably infected healthy trees by moving from infected stumps to tree roots by contacts and grafts (18, 26) or by rhizomophs in the soil (17). Mortality centers are formed as trees around infected stumps die. Trees within disease centers exhibited various foliage symptoms (Fig. 3). Recently infected trees were yellow; as they died their foliage turned red and then brown. A year or more after death, trees lost their foliage. Mycelial fans (Fig. 4) were common at the base of infected trees.

Incidence of *A. mellea* ranged from 1.7% of the transect surveyed trees at Mill Creek (Routt National Forest) to 11.2% at Last Chance (White River National Forest (Table 2). Incidence for all four stands averaged 4.5%. Density of root diseased trees also varied among the sampled sites; average for all four sites was 4.5 diseased trees per acre. Since evaluation plots were located within existing infection centers, disease incidences were higher at these sites than from transects. *Armillariella mellea* was positively identified on only 0.5% of the total live trees surveyed, whereas the pathogen was found on over 74% of the dead trees surveyed (Table 3). Other trees may have been killed by *A. mellea* or other root pathogens even though signs of disease (mycelial fans, rhizomorphs, and sporophores) were not apparent. Other investigators (5, 10, 15, 16) have suggested close associations between root disease and bark beetle activity. However, sampled trees in this evaluation were too small for successful bark beetle attacks which might hasten mortality.

1/ foliage condition classes - based on the foliage color:

G = green; Y = yellow; R = red; Br = brown; Bl = black

Table 2. Incidence of *Armillariella mellea* root disease within selected young conifer stands on the Routt, Gunnison, and White River National Forests.

Site	National Forest	Transect [1]					Evaluation Plot [2]		
		Area Surveyed (acres)	Total Trees Sampled	No. Root Diseased	Percent Root Diseased	No. Dis. Trees/Acre	Total Trees Sampled	No. Root Diseased	Percent Root Diseased
Mill Creek	Routt	13.0	582	10	1.7	0.8	295	39	13.2
Powderhouse	Gunnison	6.9	786	19	2.4	2.8	312	53	17.0
Canyon Creek	Gunnison	6.2	582	24	4.1	3.9	420	81	19.3
Last Chance	White River	4.5	536	60	11.2	13.3	514	71	13.8
TOTALS		30.6	2489	113	4.5	3.7	1541	244	15.8

[1] Includes trees sampled from transects through stands.

[2] Includes trees sampled within evaluation plots established in stands.

Table 3. Incidence of *Armillariella mellea* root disease on live and dead trees sampled within selected young conifer stands on the Routt, Gunnison and White River National Forests.

Site	National Forest	Transect [1]				Evaluation Plots [2]	
		Live Trees		Dead Trees		Percent Trees with Root Disease	
		Percent with Root Disease	No. Trees/Acre with Root Disease	Percent with Root Disease	No. Trees/Acre with Root Disease	Live Trees	Dead Trees
Mill Creek	Routt	0	0	43.5	0.8	2.3	87.5
Powderhouse	Gunnison	0.5	0.6	60.6	2.2	4.8	90.9
Canyon Creek	Gunnison	0	0	68.6	3.9	1.2	93.9
Last Chance	White River	1.5	1.6	98.1	11.8	0.9	89.3
TOTALS		0.5	0.4	74.4	3.3	2.1	90.0

1/ Includes trees sampled from transects through stands.

2/ Includes trees sampled within evaluation plots established in stands.

Distribution of foliar symptoms among trees within the evaluation plots is summarized in Table 4. Although *A. mellea* was found on only a few green trees, the pathogen was common on trees with yellow or necrotic foliage. Red color was the best foliage indicator of disease; the fungus was located in over 92% of these trees. Actual disease incidence may have been greater than we found, i.e., incipient infection of roots, which would not elicit foliar response, were not sampled. Therefore, our data on incidence may have underestimated actual disease occurrence.

Root disease incidence was not uniform throughout surveyed stands. Certain portions of stands had many dead or dying trees, whereas elsewhere there were few or no symptomatic trees. This variability may have been due to differences in stump infection, which was directly related to tree infection during the previous rotation. *Armillariella mellea* may be ubiquitous in forest soils and colonize most tree roots without causing disease until trees are stressed or cut. The fungus also exists as clones with different pathogenic capabilities (1, 19, 21). Differences in fungal clones and host susceptibility may account for observed differences in disease incidence.

Sampled stands were not significantly affected by root disease. There were sufficient numbers of healthy residual trees to maintain adequate stocking. However, if trees continue to die rapidly throughout the rotation, adverse impacts may occur. Monitoring the evaluation plots may help to improve our ability to predict the future role of root diseases in commercial stands and to assess the necessity for control measures.

Table 4. Distribution of foliar symptoms among trees within plots established to evaluate root disease epidemiology on selected young conifer stands on the Routt, Gunnison, and White River National Forests.

Site	National Forest	Percentages [1]	Symptom Classes					
			Green	Yellow	Red	Brown	Black	Totals
Mill Creek	Routt	RD	1.6	50.0	87.5	85.7	80.0	13.2
		T	85.1	1.3	2.7	2.4	8.5	100.0
Powderhouse	Gunnison	RD	2.3	100.0	100.0	100.0	86.2	17.0
		T	83.6	2.2	2.2	2.6	9.4	100.0
Canyon Creek	Gunnison	RD	0.6	100.0	100.0	88.9	93.9	19.0
		T	80.0	0.5	1.7	2.1	15.7	100.0
Last Chance	White River	RD	0	67.7	80.0	80.5	77.8	13.8
		T	84.2	1.2	3.1	8.0	3.5	100.0
TOTALS		RD	0.9	78.9	92.7	84.6	87.7	13.9
		T	83.1	1.2	2.5	4.2	9.0	100.0

[1] RD = Percentage of trees within a particular symptom class that were root-diseased with *Armillariella mellea*.

T = Percentage of total trees within a particular symptom class.

LITERATURE CITED

1. ANDERSON, J. B., R. C. ULLRICH, L. F. ROTH, and G. M. FILIP. 1979. Genetic identification of clones of Armillaria mellea in coniferous forests in Washington. Phytopathology 69: 1109-1111.

2. GOHEEN, D. J. and F. W. COBB, JR. 1978. Occurrence of Verticicladiella wagenerii and its perfect state, Ceratocystis wageneri sp. nov. in insect galleries. Phytopathology 68:1192-1195.

3. GOHEEN, D. J. adn E. M. HANSEN. 1978. Black stain root disease in Oregon and Washington. Plant Dis. Reptr. 62: 1098-1102.

4. HANSEN, E. M. 1978. Incidence of Verticicladiella wagenerii and Phellinus weirii in Douglas-fir adjacent to and away from roads in western Oregon. Plant Dis. Reptr. 62:179-181.

5. HERTERT, H. D., D. L. MILLER, nad A. D. PARTRIDGE. 1975. Interaction of bark beetles (Coleoptera:Scolytidae) and root rot pathogens in grand fir in Northern Idaho. Can. Ent. 107:899-904.

6. HINDS, T. E. and F. G. HAWKSWORTH. 1966. Indicators and associated decay of Engelmann spruce in Colorado. USDA For. Serv., Rocky Mt. For. and Range Exp. Sta. Res. Pap. RM-25. 15 p.

7. HINDS, T. E., F. G. HAWKSWORTH, and R. W. DAVIDSON. 1960. Decay of subalpine fir in Colorado. USDA For. Serv., Rocky Mt. For. and Range Exp. Sta. ~~Res~~ Sta. Pap. RM-51. 13 p.

8. JAMES, R. L. 1979. Fomes annosus on white fir in Colorado. Plant Dis. Reptr. 63:129-130.

9. JAMES, R. L. and L. S. GILLMAN. 1979. Fomes annosus on white fir in Colorado. USDA For. Serv., State and Private Forestry, Rocky Mt. Region, Tech. Rep. R2-17, 9 p.

10. JAMES, R. L. and D. J. GOHEEN. 1980. Distribution and characteristics of conifer root diseases on the San Isabel, Rio Grande, San Juan, and Grand Mesa National Forests in Colorado. USDA For. Serv., State and Private Forestry, Rocky Mt. Region, Bio. Eval. R2-80-4 (In preparation) .

11. JAMES, R. L. and C. K. LISTER. 1978. Insect and disease conditions of pinyon pine and Utah juniper in Mesa Verde National Park, Colorado. USDA For. Serv., State and Private Forestry, Rocky Mt. Region, Bio. Eval. R2-78-4, 16 p.

12. JOHNSON, D. W. and F. G. HAWKSWORTH. 1977. Shoestring root rot in a lodgepole pine stand. Poudre Ranger District, Arapaho and Roosevelt National Forests. USDA For. Serv., State and Private Forestry, Rocky Mt. Region, Bio. Eval. R2-77-22, 4 p.

13. JOHNSON, D. W., T. D. LANDIS, and L. S. GILLMAN. 1976. Rocky Mountain juniper, a new host of Armillariella mellea in Colorado. Plant Dis. Reptr. 60:886.

14. LANDIS, T. D. and L. B. HELBURG. 1976. The distribution and ecology of black stain root disease. Plant Dis. Reptr. 60:713-717.

15. LANE, B. B. and D. J. GOHEEN. 1979. Incidence of root disease in bark beetle-infested eastern Oregon and Washington true firs. Plant Dis. Reptr. 63:262-266.

16. MILLER, D. L. and A. D. PARTRIDGE. 1974. Root rot indicators in grand fir. Plant Dis. Reptr. 58:275-276.

17. MORRISON, D. J. 1976. Vertical distribution of Armillaria mellea rhizomorphs in soil. Trans. Brit. Mycol. Soc. 66:393-399.

18. PIELOU, E. C. 1965. The spread of disease in patchily-infected forest stands. For. Sci. 11:18-26.

19 RAABE, R. D. 1972. Variation in pathogenicity and virulence in single spore isolates of Armillaria mellea. Mycologia 64:1154-1159.

20. SHAW, C. G. III. 1977. Armillaria isolates from pine and hardwoods differ in pathogenicity to pine seedlings. Plant Dis. Reptr. 61:416-418.

21. SHAW, C. G. III. and L. F. ROTH. 1976. Persistence and distribution of a clone of Armillaria mellea in a ponderosa pine forest. Phytopathology 66:1210-1213.

22. SHOPE, P. F. 1931. The Polyporaceae of Colorado. Annals of the Missouri Botanical Garden. 18:287-456.

23. TEGETHOFF, A. C. 1973. Known distribution of Fomes annosus in the Intermountain Region. Plant Dis. Reptr. 57:407-410.

24. WAGENER, W. W. and J. L.MIELKE. 1961. A staining-fungus of ponderosa, jeffrey, and pinyon pines. Plant Dis. Reptr. 45:831-835.

25. WEISS, M. J. and J. W. RIFFLE. 1971. Armillaria root rot in a ponderosa pine plantation in New Mexico. Plant Dis. Reptr. 55:823-824.

26. WHITNEY, R. D. and D. T. MYREN. 1978. Root-rotting fungi associated with mortality of conifer saplings in northern Ontario. Can. J. For. Res. 8:17-22.

27. WILLIAMS, R. E. 1971. The root rot problem in the Northern Region. USDA For. Serv., State and Private Forestry, Northern Region, Insect and Disease Report 71-43, 7 p.

A P P E N D I X

Mill Creek Evaluation Plots

Hahn's Peak R.D., Routt N.F.

Plot #1 Painted site stump is 0.4 miles west of Mill Creek. Plot center (stump - tag #1) is 92 feet at 184° from the painted site stump.
Tag # 1 - 73

Plot #2 Plot center (stump - tag #75) is 330 feet at 160° from the center of plot #1.
Tag # 74 - 103

Plot #3 Plot center (stump - tag #104) is 287 feet at 141° from the center of plot #2
Tag # 104 - 144

Plot #4 Plot center (stump - tag #145) is 507'7" at 92° from the center of plot #3
Tag # 145 - 229

Plot #5 Plot center (stump - tag #230) is 446' at 100° from the center of plot #4
Tag # 230 - 282

Powderhouse Evaluation Plots

Cebolla R.D., Gunnison N.F.

Plot #1 Plot center (stump - tag #1) is 245 feet at 106° from a painted tree on the edge of a mature stand on the west side of the border road.
Tag # 1 - 28

Plot #2 Plot center (stump - tag #29) is 470 feet south of a painted tree on the left side of the border road, then 29 feet east of the road middle.
Tag # 29 - 100

Plot #3 Plot center (stump - tag #101) is 256 feet at 158° from the center of Plot #2
Tag # 101 - 196

Plot #4 Plot center (stump - tag #197) is 536 feet at 43° from the center of Plot #3
Tag # 197 - 318

Plot #5 Plot center (stump - tag #319) is 360 feet at 348° from the center of Plot #4
Tag # 319 - 351

Plot #6 Plot center (stump - tag #352) is 62 feet at 63° from the center of Plot #5
Tag # 352 - 384

Canyon Creek Evaluation Plots

Cebolla R. D., Gunnison N.F.

Plot #1 Plot center (stump - tag #1) is 469 feet at 31° from a painted tree at the road intersection
Tag # 1 - 94

Plot #2 Plot center (stump - tag #95) is 386 feet at 349° from the center of Plot #1
Tag # 95 - 174

Plot #3 Plot center (stump - tag #175) is 352 feet at 20° from the center of Plot #2
Tag # 175 - 238

Plot #4 Plot center (stump - tag #239) is 386 feet at 11° from the center of Plot #3
Tag # 239 - 360

Plot #5 Plot center (stump - tag #361) is 402 feet at 47° from the center of Plot #4
Tag # 301-396

Plot #6 Plot center (stump - tag #397) is 141 feet at 234° from painted tree (orange horizontal stripes) south of Stridiron Creek Road
Tag # 397 - 461

Last Chance Evaluation Plots

Sopris R. D., White River N. F.

Plot #1 Plot center (stump - tag #1) is 47 feet at 62° from a flagged aspen south of the road
Tag # 1 - 70

Plot #2 Plot center (stump - tag #71) is 162 feet at 122° from the center of Plot #1
Tag # 71 - 300

Plot #3 Plot center (stump - tag #301) is 138 feet at 60° from the center of Plot #2
Tag # 301 - 969

Plot #4 Plot center (stump - tag #970) is 244 feet at 22° from the center of Plot #3
Tag # 970 - 1000, 101.